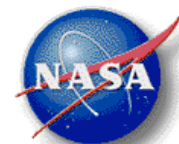


# **FLIGHT RESEARCH USING AirSTAR**

Kevin Cunningham  
AirSTAR Principal Investigator  
October 26, 2007



# Aviation Safety Program

## Integrated Resilient Aircraft Control Project

### V&V Methods and Testbeds

#### Objective:

Validate technologies developed in IRAC for recovery from loss-of-control flight conditions and damage scenarios.

Provide:

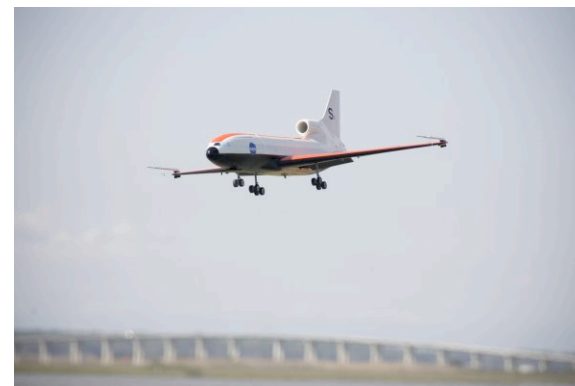
- Verifiable control law implementations
- Predictive analysis tools for uncertain systems
- Experimental research capability

#### Focus:

Foundational work in four areas:

- Software Safety Assurance in Adaptive Systems
- Probabilistic Methods for Confidence in Control
- Subscale flight testbeds
- Fullscale flight testbeds

### Flight Research Testbeds



Subscale – S2 at Wallops

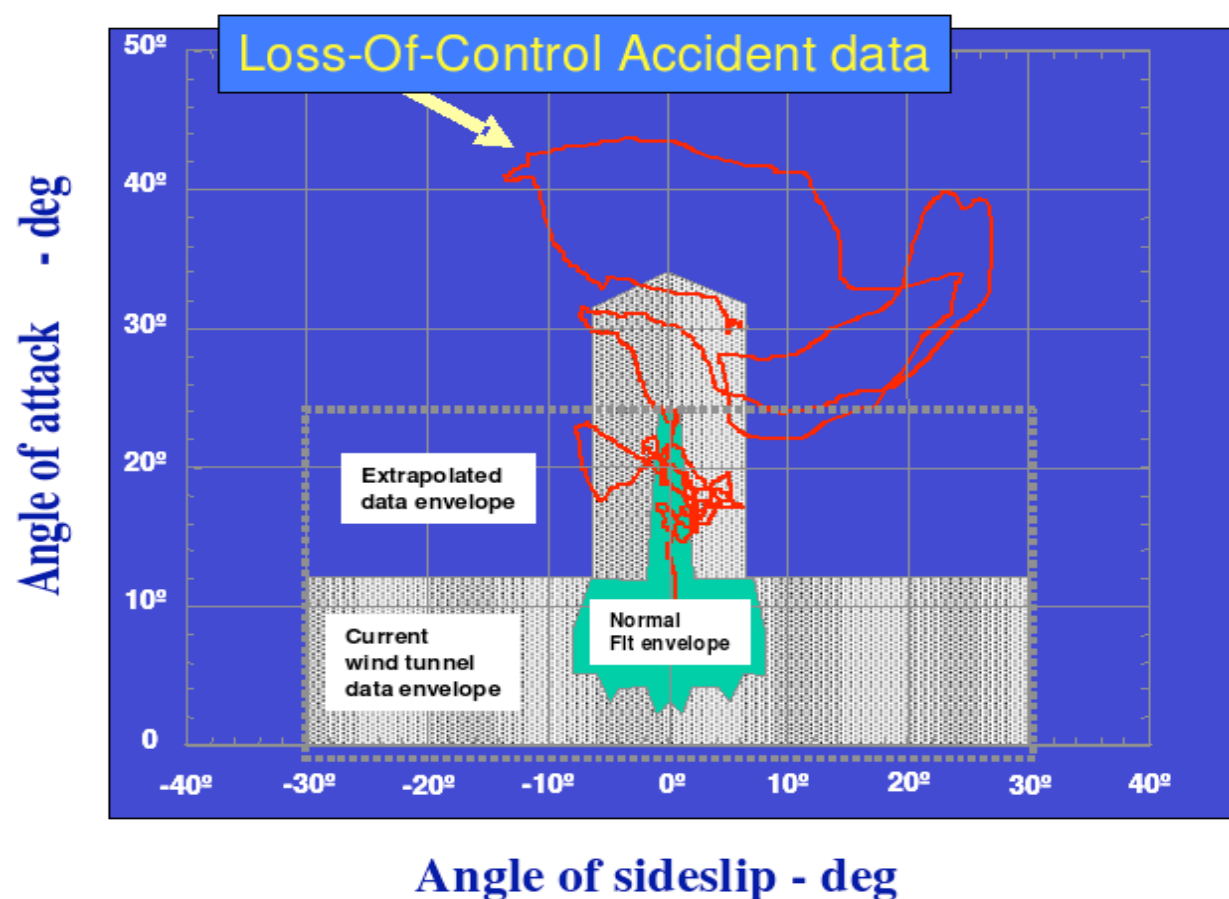


Fullscale – F15B at Dryden



# Motivation for Subscale Testing

*IRAC research is focused on loss-of-control, failure and damage scenarios, and their mitigation through the application of adaptive control.*





# AirSTAR: Operational Concept

## Operations out of Wallops Flight Facility

- Restricted Airspace, excellent operations support
- Two Pilot system
  - *Safety Pilot* – RC control, line-of-sight, takeoff/landings
  - *Research Pilot* – up and away, research maneuvers

## Multiple Vehicles/Common Avionics Suite

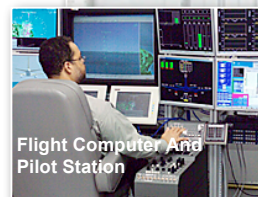
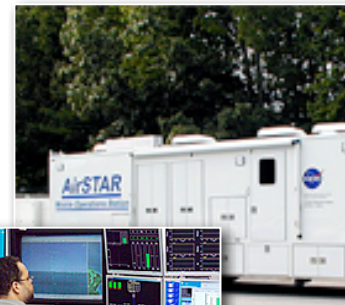
- Reuse INS/GPS, AirData and RF telemetry system

## Researcher Friendly Infrastructure

- Flight Control implemented on the ground
- Real-time Simulink autocode
- Real-time signals available as system based on network stream

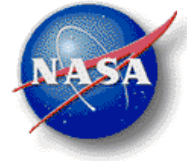


UAV Runway WFF

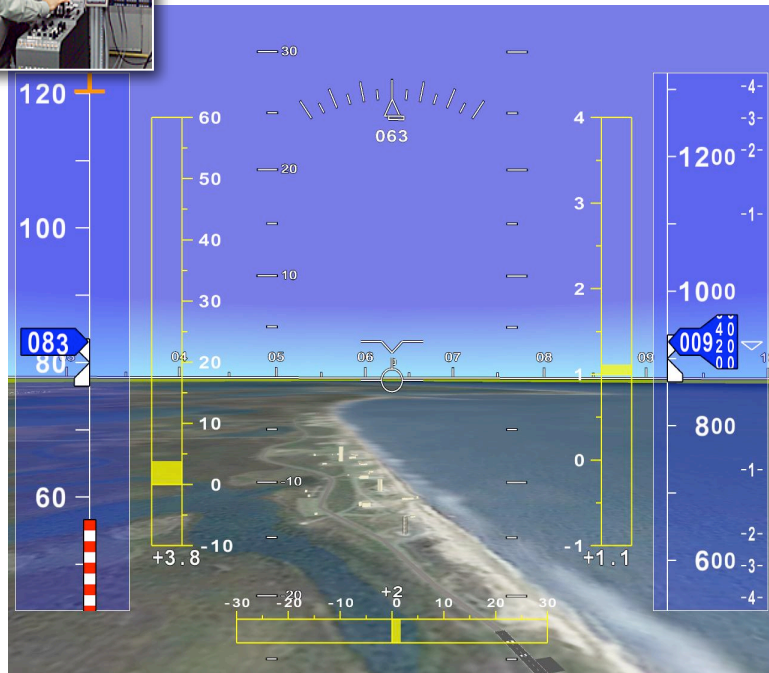


Pilot Station MOS

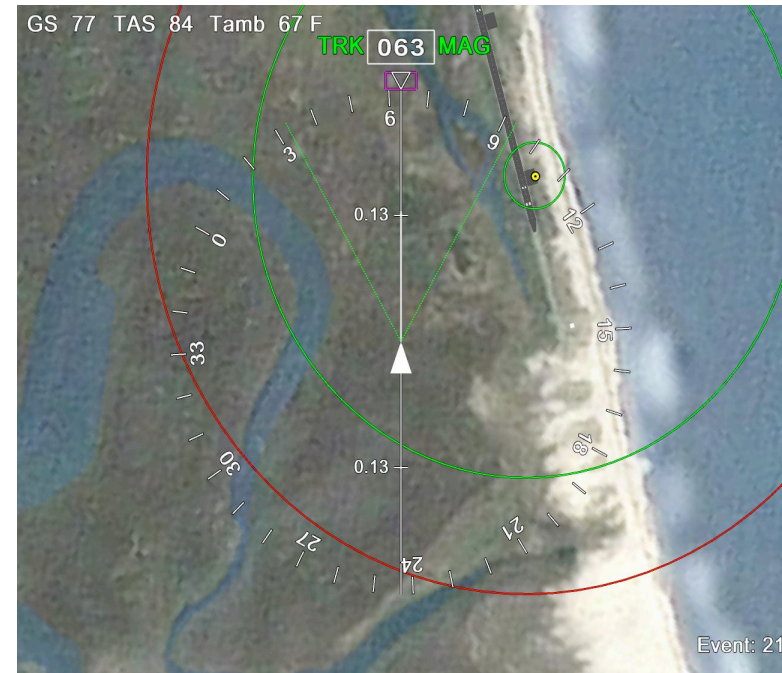




# Research Pilot Station



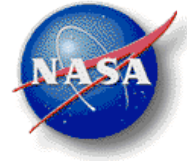
HUD- Primary Flight Display



Navigation Display

## Research Pilot Interface:

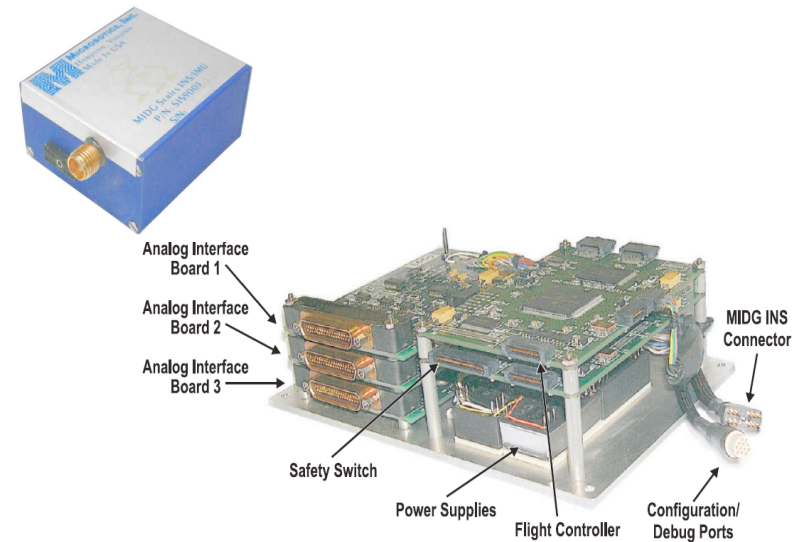
- Heads Up Display: Synthetic Vision with realistic terrain and instrument overlay
- Navigation Display: Operation range, magnetic heading, turn projection
- Nose Camera: Analog Video feed from nose mounted camera
- Tracker Camera: Analog Video feed from ground based telescope/tracking system



# Avionics and Telemetry

## Micro INS Unit (55g, 1.6"x1.5"x0.8")

- GPS derived position and velocity
- Magnetometer measurements
- 3-axis micro-gyro, 3-axis Accelerometers
- Kalman Filter based Navigation Solution (50Hz):
  - Euler Angles/Quaternions
  - Position/Velocity/Acceleration Estimates
  - Angular rates



## Flight Computer:

- 32 Analog Inputs (Surface Positions, Alpha/Beta Vanes, Pressure)
- 32 Pulse Width Modulated Outputs (Actuation Servos)
- 3 Serial Ports (INS data, ECU data, RTCM corrections)

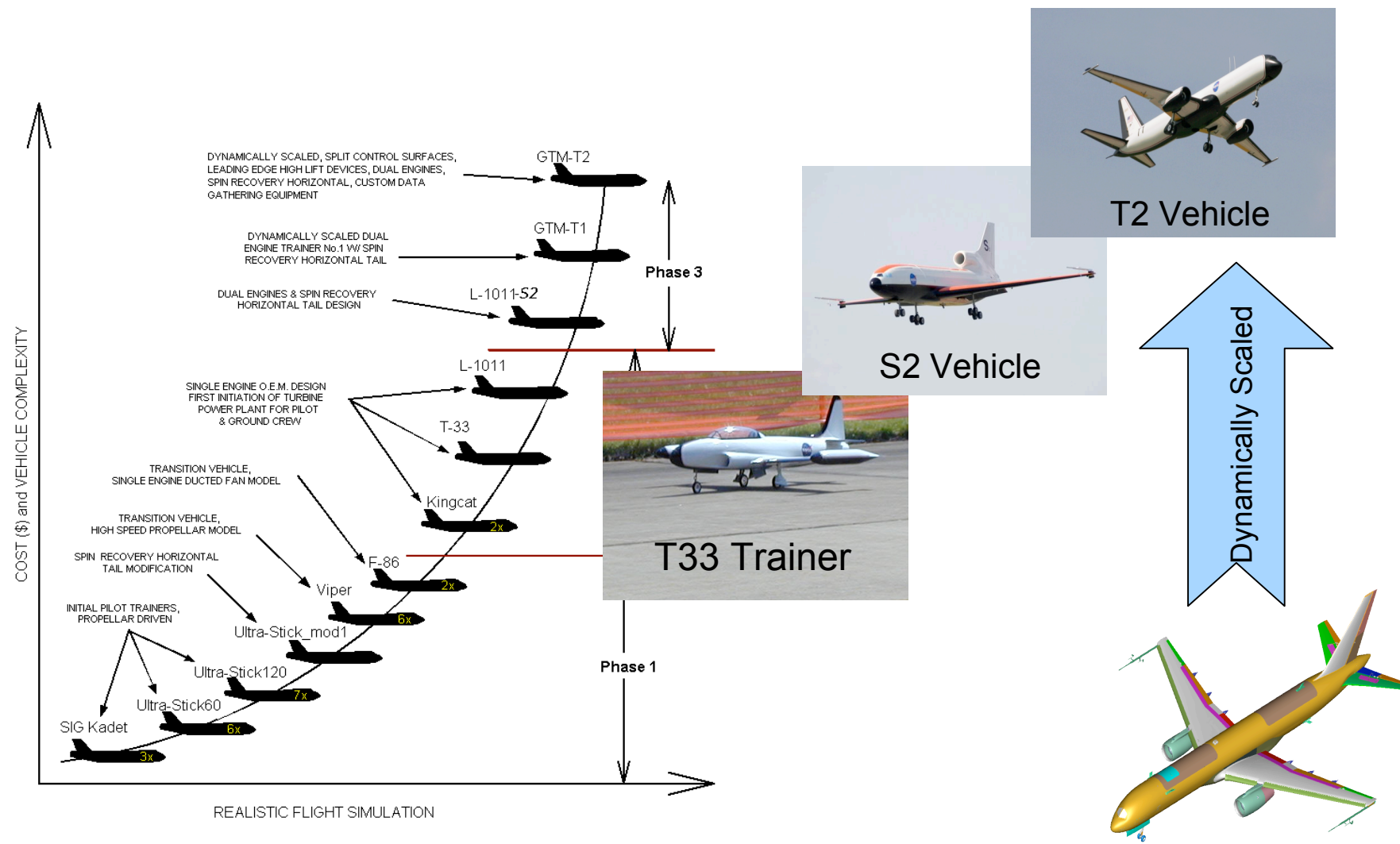
## Telemetry:

- Downlink: Video, 46 Data Channels, 216 Hz frame-rate S-band
- Uplink: 31 Data Channels, 216 Hz frame-rate, L-band





# AirSTAR Vehicles

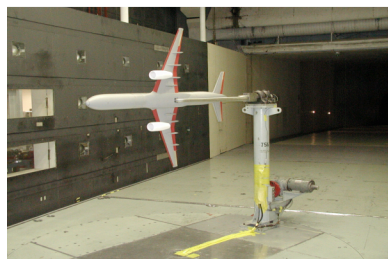




# Generic Transport Model (T2)



Static rig



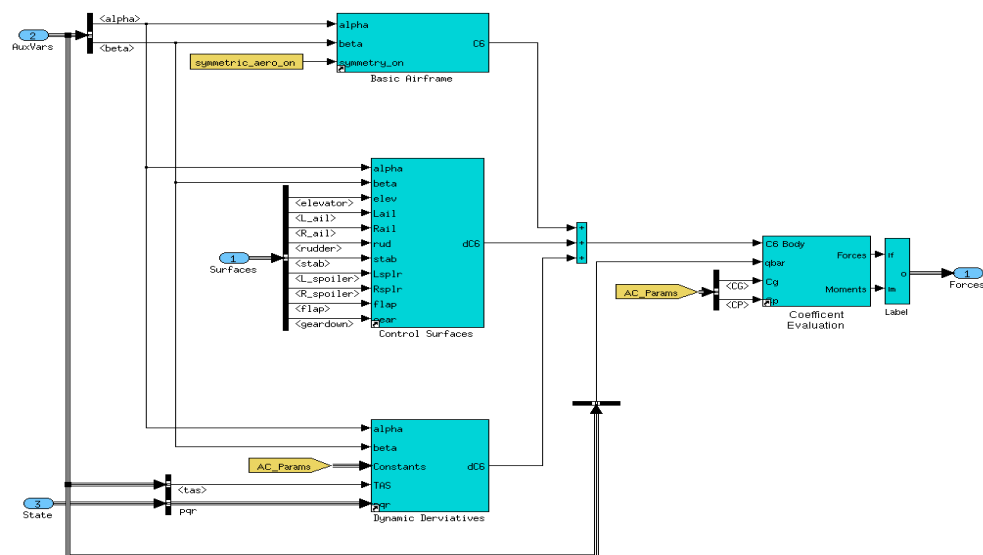
Forced oscillation rig



Rotary balance rig

## Extended Aero Database:

- Static data: -5 to 90 deg range AoA and -45 to 45 deg range in Sideslip
- Control Surface Increments over Alpha/Beta Grid.
- Dynamic Increments from Forced Oscillation Test Data
- Dynamic Increments from Rotary Balance Test Data
- Validation Data (Free-Spin) from Spin Tunnel Tests



Simulink Based Flight Dynamics Model

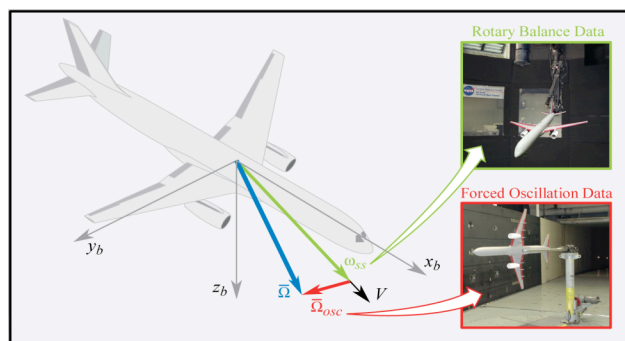
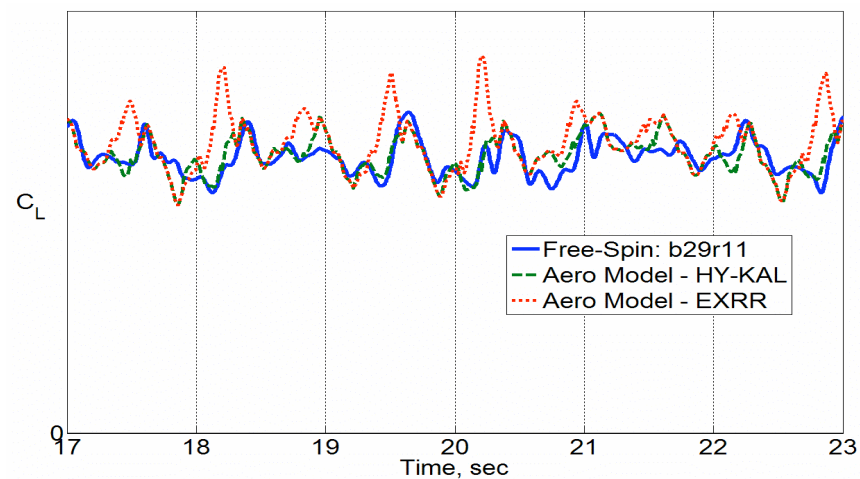




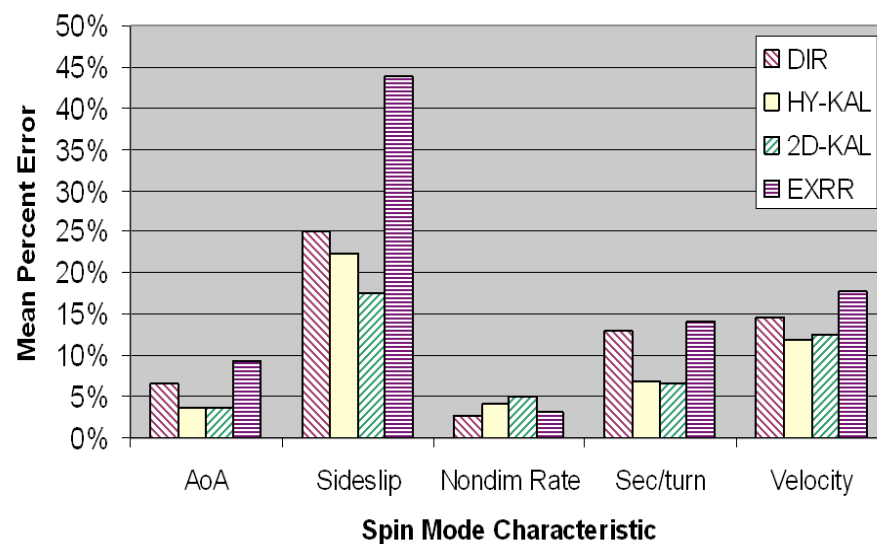
# Validation of the Aero-Database



Free-Spin Testing, 2% scale model



Blending Techniques for Rotary Balance and Forced Oscillation Data

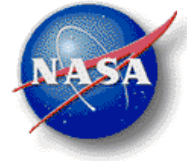




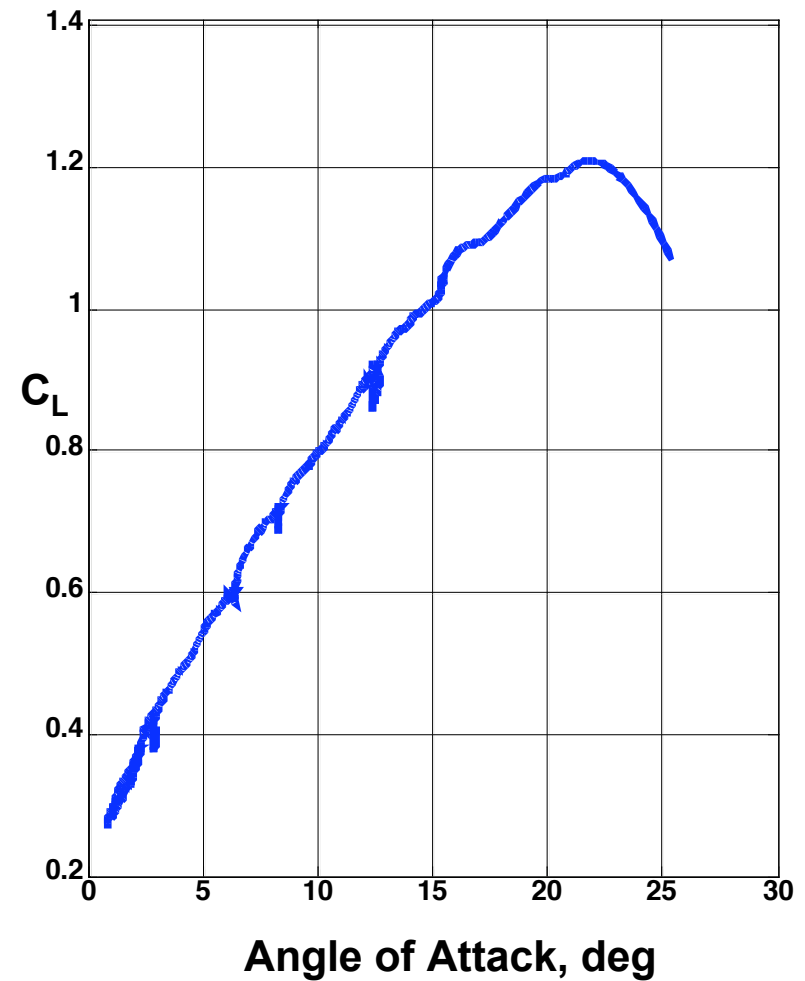
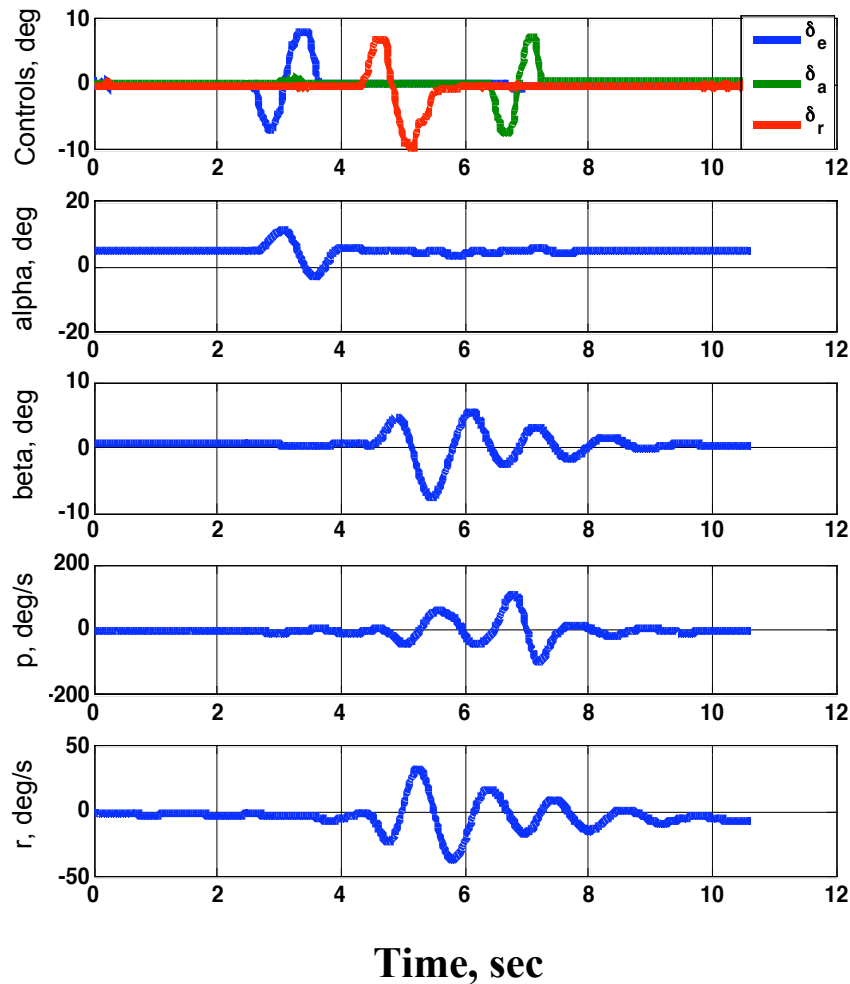
# Flight Video

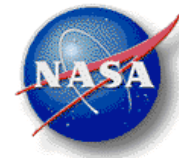




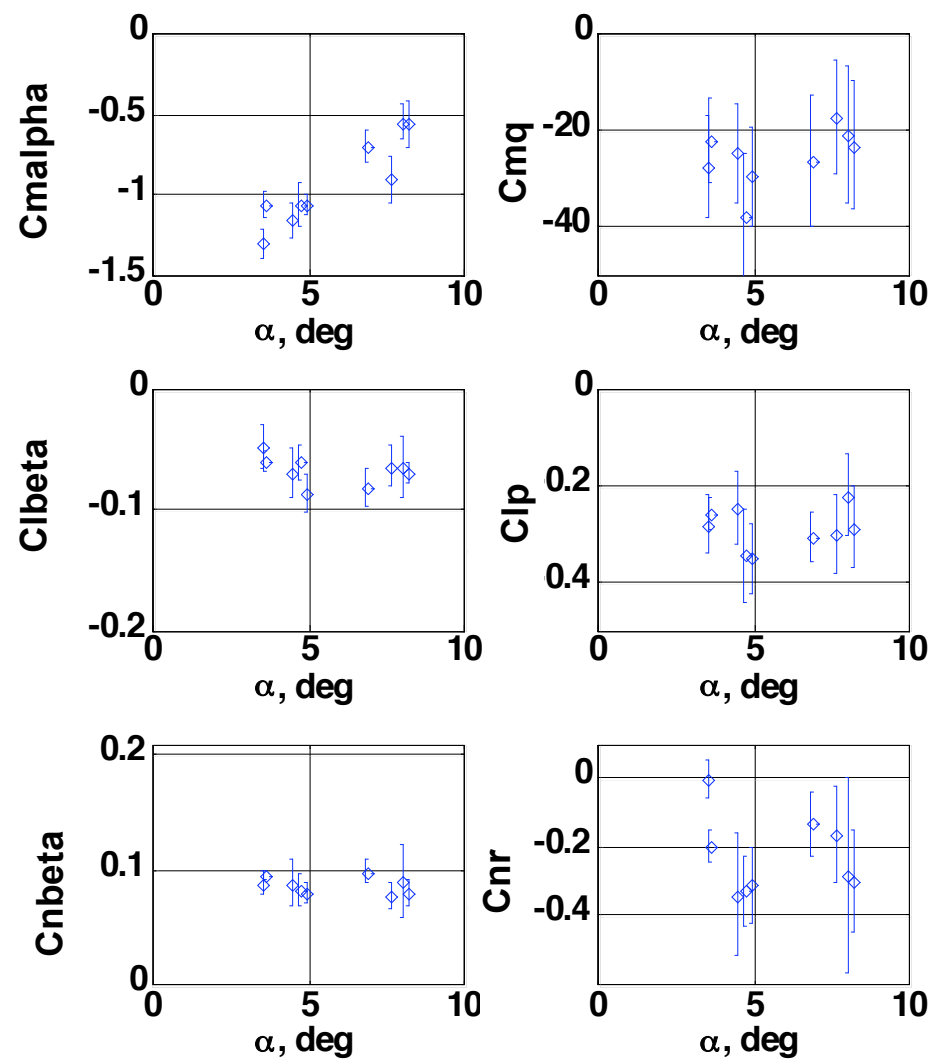
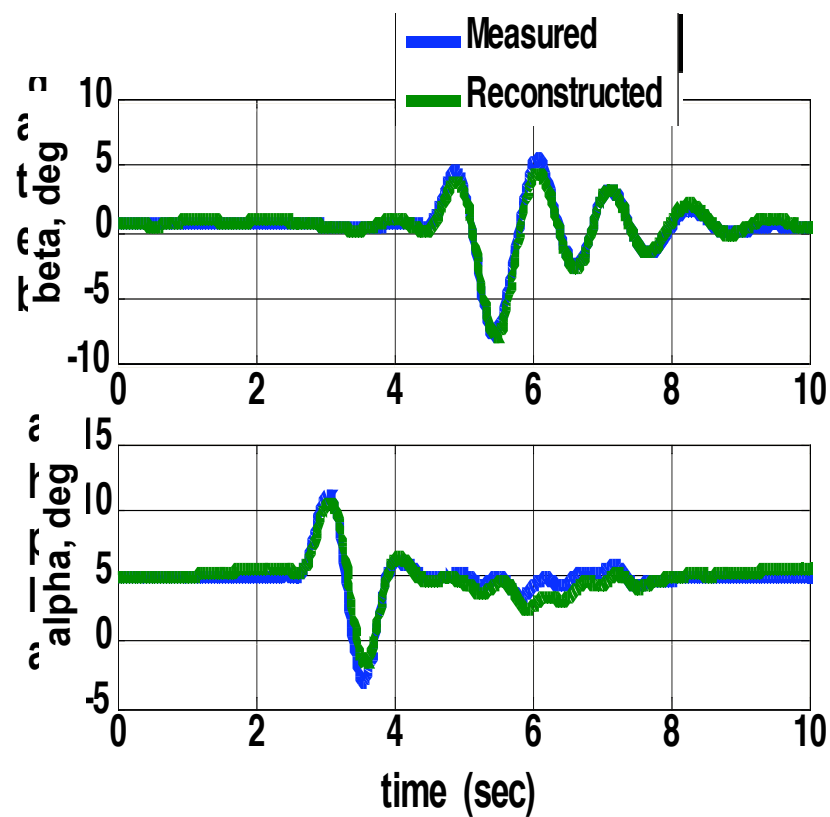


# Flight Data





# Results

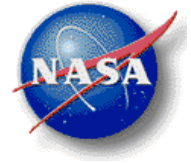




# Concluding Remarks


- The AirSTAR system is a maturing capability to collect quantified data for flight dynamic modelling and control law evaluations in high-risk flight conditions.
- The potential for rapid prototyping of control algorithms and flight-time evaluation of performance allow for efficient operations and design-test-design iterations.
- We are seeking to establish awareness and cooperative technology development ventures related to flight control laws, system identification, and flight dynamics.
- If interested, please contact us.





# Contacts

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If you have further questions today, please  
see a Partnership Consultant  
(look for a Bright Yellow badge)  
or visit the booth on  
How to work with Langley